CLIMATE CHANGE IMPACT ON HILL AGRICULTURE AND FARMERS ADAPTIVE STRATEGIES

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CONTENTS

CLIMATE CHANGE IMPACT ON HILL AGRICULTURE AND FARMERS ADAPTIVE STRATEGIES: *A CASE STUDY OF KULLU VALLEY IN HIMACHAL PRADESH*

Abstract

This study conducted during January-March,2007, in the Kullu Valley of Himachal Pradesh in India, takes the apple as an indicator crop to investigate the positive and negative effects of climate change on farm economy. It explores the impacts it had on the agricultural economy of the hill farmers who were forced to abandon apple farming, and those to whom apple farming came to be a new option.

This research attempts to piece together evidence and aims to enhance our understanding of climate change impacts as observed by farming communities at very local levels. The growing threat of global warming and its effects and prevailing obscurities about the future of agriculture are all addressed in this investigation. The research is a field study to determine the agricultural and socioeconomic impact of climate change on the farmers' apple economy of the Kullu Valley in Himachal Pradesh, India. The essay determines the impact of global warming on apple farmers and their farm/household economy in four villages situated at two different locations in Kullu valley, Himachal Pradesh. One was higher up North whereas the other was at the Southern end of the Valley. Data was collected by interviewing twenty farmers in each location using structured questionnaires. Further, six key informants consisting of lead farmers and scientists were interviewed and discussions were conducted on the issue. Any necessary weather data was obtained from two weather stations located in the valley. The findings showed that the apple belt was shifting upwards due to climbing regional temperatures, making the lower parts of the valley unsuitable and the upper valley hospitable for the apple crop. This brought a short period of economic decline in the lower valleys, but with government support, the farmers were able to diversify and regenerate their farm economies by introducing new crop varieties into the area. Presently farmers in the upper valley are prospering with the apples. The future of world agriculture is unclear as its impacts vary regionally, but it will not always be positive. In order to mitigate climate change from severely hindering such economic activities, actions at all levels – individual, institutional, national and international - have to be taken before it is too late.

CLIMATE CHANGE IMPACT ON HILL AGRICULTURE AND FARMERS ADAPTIVE STRATEGIES: *A CASE STUDY OF KULLU VALLEY IN HIMACHAL PRADESH*

The Global Warming as an Issue

Global Warming is an ever increasing threat to our planet that is becoming impossible to overlook. The Greenhouse Gases (GHG) namely methane, CO_2, carbon monoxide, oxygen, water vapour and nitrous oxides which are found in high concentrations in the troposphere region of the Earth's atmosphere play a crucial role in the process called the Greenhouse Effect. The sun gives off short wavelength ultra- violet rays which are absorbed by the Earth's surface, in turn giving off long wavelength infra-red radiation. Part of this radiation escapes through the atmosphere, while the remaining is reflected back by the GHGs. The trapped infra-red radiation, with its heating properties, has a warming effect on the globe, called global warming.

'This process is necessary in order for the Earth to sustain hospitable temperatures for living organisms'[1], however in the recent decades especially *'since the beginning of the industrial revolution, atmospheric concentrations of carbon dioxide have increased nearly 30%'*[2]. A prodigious growth in human activities, primarily burning of fossil fuels and mining has released massive amounts of the responsible gases into the air. The atmosphere has faced an unprecedented increase in the levels of GHGs causing more heat to remain trapped within the atmosphere. However, for this condition, today's increasingly extravagant lifestyles hold as much responsibility as industrial activity.

Global warming interlinks directly with the climate and as a result, rising temperatures are causing various changes in general weather patterns all over the world.

Scientists have painted dismal pictures regarding the consequences of climate change on the environment and its influences on human activities and wellbeing. Although less confident concerning local levels, they are able to conclude without as much obscurity the general effects climate change is having on a global level such as melting glaciers, rising sea levels, changing weather patterns etc. which may lead to increased flash floods, drought, storms.

These hypotheses are merely indicating the likely consequences of what may happen if we continue living the way we are and do not make any effort to change our thinking and lifestyle. The eventual effects of global warming on people are rather lucid. Changes in climate could create optimal conditions for the growth of harmful bacteria and viruses resulting in widespread diseases that may grip the population; mass migration may stress

[1] Flannery, T. (2005). *"The Weather Makers"* London: Penguin Group

[2] US Environmental Protection Agency, *"Global Warming- Climate"*. http://yosemite.epa.gov/OAR/globalwarming.nsf/content/climate.html. Accessed June 6, 2006

resources in areas and possibly '*threaten political stability*'[3]. It is an elongated process which has been and is continuously affecting all areas of our lives and surroundings. Climbing average global temperatures are slowly transforming the way our system works; the environmental quality, world agriculture and food security are all at stake. There are many impacts the people will most likely experience locally even before the large scale effects are noted globally. One such local effect this piece of research examined, is the climate induced changes on agriculture and livelihoods, in a mountain valley.

Most agricultural crops are sensitive to their growing conditions- especially rainfall and temperature which consequently come under the key factors influenced by climate change. It is easily predictable therefore, how variations in annual weather and changing climate may affect their production and growth.

It is fairly easy to imagine completely dire prospects for world agriculture. It could definitely end up that way. But as of yet, we only know that crop yields are being altered- this could mean in either positive or negative ways. The effects on agriculture and its consequences on the society are likely to differ locally depending on the type of climate change that has taken place in that area and the options available to farmers. It may well bring new agricultural systems to areas and replace the old crops and farming systems.

Britain has identified that *'Climate change provides many new opportunities for British farmers'*[4] whereas Tim Flannery, in his edition of 'The Weather Makers' reported that less rainfall during the wheat season has driven Australian farmers out of wheat farming and they are now taxi drivers in Perth; waiting to sell their land for peanuts[5].

[3] Hiscock, G. *"Warming 'threat to Asian security, Grim scenario of disease and disaster"*. June 13, 2006

[4] Hunt, N., 'Climate Change Brings New Options for UK Farming', July, 2006
http://www.planetark.com/dailynewsstory.cfm/newsid/37099/story.htm

[5] Flannery, T. (2005). *"The Weather Makers"* London: Penguin Group

Scope of the Study

To determine the agricultural and socioeconomic impact of climate change on the farmers' apple economy in two areas of the Kullu Valley in Himachal Pradesh, India

The Kullu valley is located in the northern part of Himachal Pradesh, a small state situated in the North-West Indian Himalayas (Annex1). In the past few decades the valley has faced a strange phenomenon. Farmers in the lower Kullu Valley have had to abandon apple farming due to certain climatic changes that eventually made it unsuitable to grow the apple crop. Simultaneously, farmers in the higher regions of the valley discovered that the conditions have been altering, making the climate hospitable towards the apple crop. This change has consequently led to a continuous upward shift of the apple belt towards the North.

This study takes the apple as an indicator crop to investigate the positive and negative effects of climate change on farm economy. It explores the impacts it had on the agricultural economy of the hill farmers who were forced to abandon apple farming, and those to whom apple farming came to be a new option.

Objectives:

This investigation attempts to answer the following questions;

- What impact has global warming had on the Kullu Valley climate?
- Are the farmers aware of this? If so, how and what impact has it had on them?
- As a consequence of climate change, has the apple belt actually shifted upwards?
- And what effect has this had on the agricultural economy of the affected areas?

Furthermore, it also aims to enhance our understanding of the issue whether climate change actually does benefit an economy by providing new farming opportunities. Due to global warming, has the diversified farming options proved to be more beneficial than the destroyed farming niche?

Methodology

Study Site

The study was conducted in five villages in two locations about 100 kilometres apart. Among these, two villages are located in the lower/southern end and three in the northern end of the valley (Annex1).

Location A- Southern Tip; Better known as the Lower Kullu Valley Fruit Belt: This area is at an average altitude of *1100-1300m*[6]. The two villages that are comprised in this study area are;

[6] Key informants: Lead Farmers: Kaushal, O.P.; Ram, T.; Lal, B.; Shrimati Manoja;

- Hurla
- Bajaura

Location B- Northern Tip; Better known as the Upper Valley: This area is at an average altitude of around *2100-2300m*[7].
The three villages comprised in this study area are;

- Burua
- Vashist
- Kothi

Data Collection

Primary Data Collection:
The most vital sources of information for this research were the farmers as they are the ones who have been experiencing the strongest effects of climate change and the shifting apple belt. For this purpose, a structured questionnaire for each location (Annex2&3) was prepared including questions on all relevant aspects of information necessary for this study. Twenty farmers from each location were selected and interviewed using the questionnaires. Furthermore, a general discussion was held on climate change and its impacts on the agricultural/household economy. In addition *six key informants*[8] including lead farmers and scientists were selected and further interviewed as they had greater awareness of the issue being discussed (Annex4&5).

Photograph 1: A Respondent Farmer

Part of the data was analysed using simple mathematical methods (percentages and averages) and part of it using statistical analysis.

Secondary Data:
Available weather data such as temperature and rainfall was collected from two weather stations located in the valley for the purpose of this study (Annex6).

Lead Scientists: Partap, T.; Partap. Interviewed 2nd- 6th July, 2006
[7] Key informants
[8] Key informants verified what farmers were generally saying is true and the responses are weaved into the findings of the survey but not specifically mentioned.

STUDY FINDINGS

LOCATION A: Lower Kullu Valley, Villages; Bajaura and Hurla

Apple farming- Boom and Decline:

Location A is a valley area dominated by small and marginal farmers. Of the average 2.71 hectares of landholding of each farmer, apple orchards occupied 70 percent of their farmland. It contributed 100% to the household income for 25 percent of the farmers and around 90% for another 50 percent. For the remaining 25 percent of the farmers, other sources held greater value- apple farming contributed an average of 43% to their income. The fact that 75 percent of the families were almost entirely dependent establishes that during the 70s-90s, apple was the leading crop and a majority of the farmers were dependent on its income. Farmers in the lower valley area planted the apple orchards around the early 60's and it dominated the farm economy and livelihoods of this area. However, during the 1980's, farmers observed a continuous decline in the apple economy for a period of 5-10 years, due to which apple farming eventually phased out from the area (Table 1).

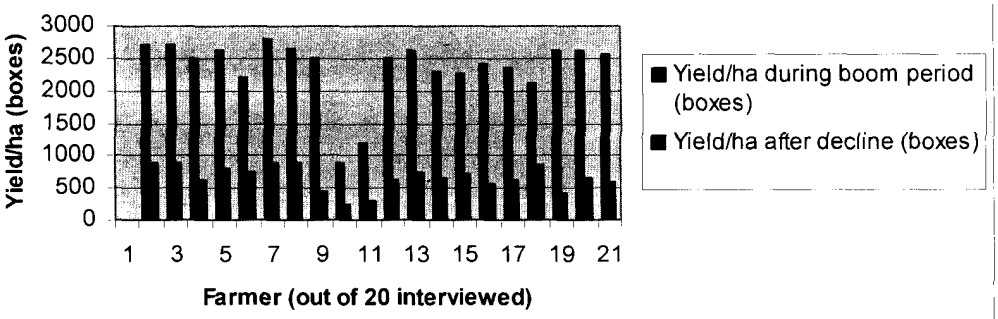
Table 1: Farmers' apple orchard holdings and income levels of surveyed households during the boom period and the changes (farmers' responses)

Parameter	Average Value	Range
Farm size (ha)	2.71	0.56-8.00
Orchard size (ha)	1.89	0.16-8.00
Contribution of apples to household income (%) before phase out	For 25% of the farmers apple contributes 100% For 50% of the farmers, apple contributes 88% For 50% of the farmers, apple contributes 43%	- 75-95 35-50%
Apples planted (year)	1956-69 (mostly early 60's)	-
Apples removed (year)	1980-95 (mostly in 80's)	-
Phase out period	5-10 years (started declining in early 80's- abrupt to phase out manner)	-

The decline in the quality and productivity of the apple crop was a gradual process. Respondents eventually observed a 2/3 reduction in total apple productivity as compared to the boom period (Figure 1). Of the surveyed farmers, 95 percent reported an annual decline in profit of between 10-25 %. The majority (60%) claimed an initial decline in

yield, followed by a decline in the quality, and the rest an initial decline in quality (Table 2).

Figure 1: A bar graph to show the contrast between the apple yield during the boom and decline period (1 box = 10kg)



The validity of the results used in the graph above is reinforced by the strong correlation coefficient of 0.7 between the yields at the two different points of time. This value

Table 2: Farmers observations of climate change impact on apple farming (percentage of response)

Parameter	% of response
Farmers observations of climate change (increase in temperature, low and erratic rainfall, occurrence of bad weather conditions such as frost, hailstorm and sudden low temperatures during apple flowering and fruit set period)	100
Impact on fruit quality (size, weight, colour etc.) • Small size, low weight, poor or no colour development	100
Initial indicators of climate change impact on apples • First decline in apple yield followed by poor fruit quality	60

signifies that the results very closely follow the same pattern for all of the twenty farmers.

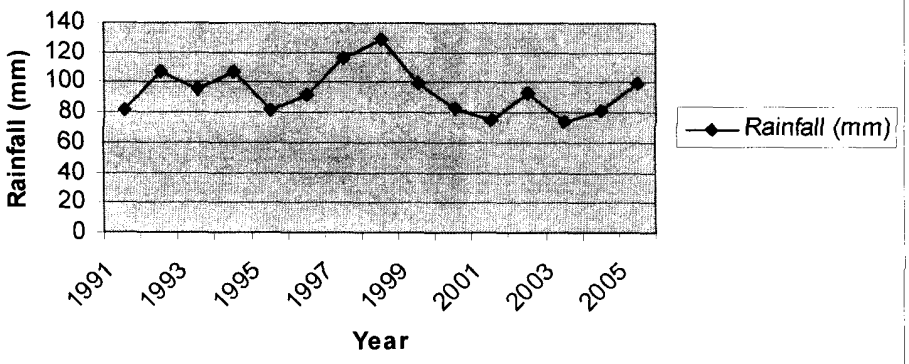
• First decline in quality followed by yield decline	40

Climate change and disappearance of the apple crop in the lower valley:

For good apple quality and yield the trees require a chilling period of about 90 days in at least 4-5 inches of snow and a moderate amount of rainfall during monsoon season to provide enough water for trees to grow. Otherwise, the crop results are not satisfying and the colour of the apple is especially affected. All of the farmers observed various climate changes (Table 2).

From what all the surveyed farmers responded and what can be deducted from the reducing colour development of the apple crops in the lower area is that temperatures have been steadily climbing. As a result, winter seasons became shorter and slightly warmer, depriving the apples of their chilling requirement. Presently, it does not snow in the surveyed areas during the winters and the summer season has also lengthened. The weather station located in Bajaura recorded a general increase of around 1°C in average annual temperature and irregular precipitation patterns throughout the valley in the last two decades (Figure 2). Furthermore, 35 percent of the farmers mentioned drought and dryness during the discourse. The key informants, in addition, reinforced what was suggested and can be seen in the figure below; precipitation patterns/rainfall etc. became irregular and erratic, due to which a lot of the apple trees dried up. Sudden hailstorms bruised and damaged the crop, immediately reducing its value in the market.

Figure 2:Annual rainfall (mm) in Bajaura, lower valley, Kullu (Source: Weather Station of CSK Himachal Pradesh)



The size, shape, weight and colour of the apples were impacted. Large apples with a symmetrical shape and full colour fetch a greater value in the market. However, what the farmers in the lower areas harvested were much smaller apples, without the right shape and poor colour with little shine (Table 2). Therefore, the apple yield received poor or in some cases, no marketing by the end. Especially varieties such as Red and Royal Delicious which are known for their red colour, suffered the most and farmers were unable to profitably market these varieties due to the poor colour development (Table 3).

Table 3: Impact of climate change on apple marketing and income (percentage of farmers' responses)	
Parameter	**% of responses**
Poor or no marketing; low price due to poor fruit quality and low production	100
Rate of profit decline per year during downfall decade	
• 10-20%	45
• 20-25%	40
• 35-40%	15

Infestations and crop care measures:

With the change in climate, farmers faced increasing challenges as the altered climate became hospitable to new pests and diseases, causing various problems such as root rot, canker and drying trees (Table 4). All of the farmers including the key informants confirmed the attack of the fungal disease called scab that struck in most parts of the valley and caused havoc during the 1980's. It affected the apple crops very harshly, reducing their market value even further. Farmers reported a substantial annual reduction in profits as is highlighted in Table 4.

Table 4: Folk indicators of climate change impact on apple farming and orchard management practices (percentage of farmers' responses)	
Parameter	% of response
Attack of pests and diseases;	
• Scab	100
• Other diseases (scale, root rot, canker, drying trees etc.)	80
Use of pesticides	100
• Increase in use of pesticides	100
Use of fertilisers	100
Increase in cost of production and lower profits	100
Additional comments: Earlier only TSO (tree spray oil- insecticide) was used; since the 80's new pesticides were introduced and use increased	

To save their crop from the increasing disease infestations, 100% farmers responded to the situation by applying more fertilisers and pesticides to protect their crop and maintain output. This increased the cost of production lowering the profit. The short term primary effects of these substances on these crops were positive, nourishing the crop, maintaining

the quality and controlling the responsible pests and diseases. However, not long after, the pests became resistant to the pesticides. These chemicals were, furthermore, killing many of the beneficial insects which included natural pest enemies, reducing their number drastically. Most significantly the honeybees which are responsible for cross pollination, declined amazingly. Reduction in pollination in turn affected fruit set which eventually led to much less yield than the potential amount. Questioned farmers also recognised the degrading impacts pesticides have on *human health*[9] and soil fertility. Fertilisers also, although beneficial for crops in the short run, have many detrimental impacts. The fertilizer use makes the soil turn hard, forming tough clumps and also affects the beneficial soil fauna such as earthworms that help keep the soil fertile and rich. In the long run, fertilisers degrade the fertility of the soil. Table 5 summarises the effects of excessive pesticide and fertiliser use.

Table 5: Effects of excessive use of fertilisers and pesticides on the apple crop (farmers' responses)

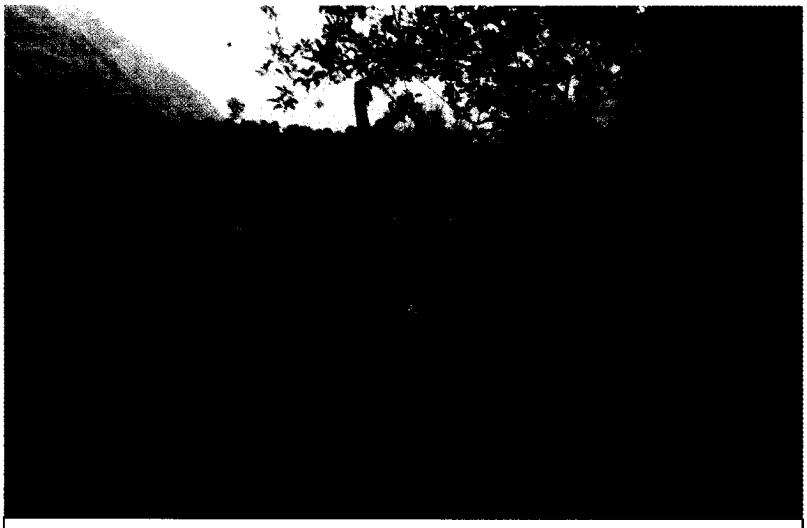
	Fertiliser	Pesticides
Positive effects	Helped maintain crop yield and quality	-Killed pests -Controlled diseases -Helped maintain crop yield and quality
Negative effects	Long term soil quality and fertility adversely affected. Soil becomes hard Affects beneficial soil micro fauna (earthworms etc.)	-Resistance of pests increased -Beneficial insects (pollinators and natural pest enemies) killed -Negative impact on soil (micro fauna) and health -Pollination affected; pest population increased -Bad for human health

All of these problems combined affected the apple crop, contributing to low productivity/quality and little market value. All the numerous pesticide and fertiliser sprays conducted on the crop made the cost of apple production increase further, simply adding to the problems apple farmers were facing with the declining economy. Eventually, as 100% of the farmers stated, high costs and low revenue gave low profit which later on started turning into losses (Table 3).

[9] Although the health aspects were not covered in the survey, during discussions, farmers revealed incidences of diseases such as cancer, high blood pressure and kidney failure increased during this period.

Post Apple Farming Period:

The phasing out of apples in the lower Kullu Valley area was a result of a chain of reactions triggered by the change in climate. After this, farmers shifted to other crops and methods of income. But it is reflected from all surveyed farmers that they did not completely abandon farming practices. All of them remained in this activity and diversified to other crop options.



Photograph 2: Tomatoes planted in plum orchard in Lower valley which was previously an apple orchard.

Out of the total, 60 percent of the previous apple orchard owners are now utilising the land to grow vegetables and other fruits for commercial purposes (Photograph 2). Over 50% of the respondents are also growing wheat and maize for subsistence purposes alongside the other crops. Today, 60 percent of the farmers rely on farming for 91% of their household income whereas the rest have other sources which make up 55% of their present income such as government jobs and land dealing.

The survey also reveals that it took most farmers (65%) 4 -5 years to restore their farm economy after the apple farming left them in loss. A greater percentage of respondents said they ended their apple orchards abruptly. They did not slowly shift to other crops while still waiting to see if the apple economy would restore itself as most of them could not afford to do so. The major vegetable crops grown in this area nowadays are cabbages, tomatoes, brinjal, potatoes and chillies and the major fruit crops are plums, pomegranates etc. The variety is quite large and 40 percent of the questioned said it was much more beneficial than apples, 45 percent said it was less beneficial while 15 per cent said that it was almost the same (Table 6).

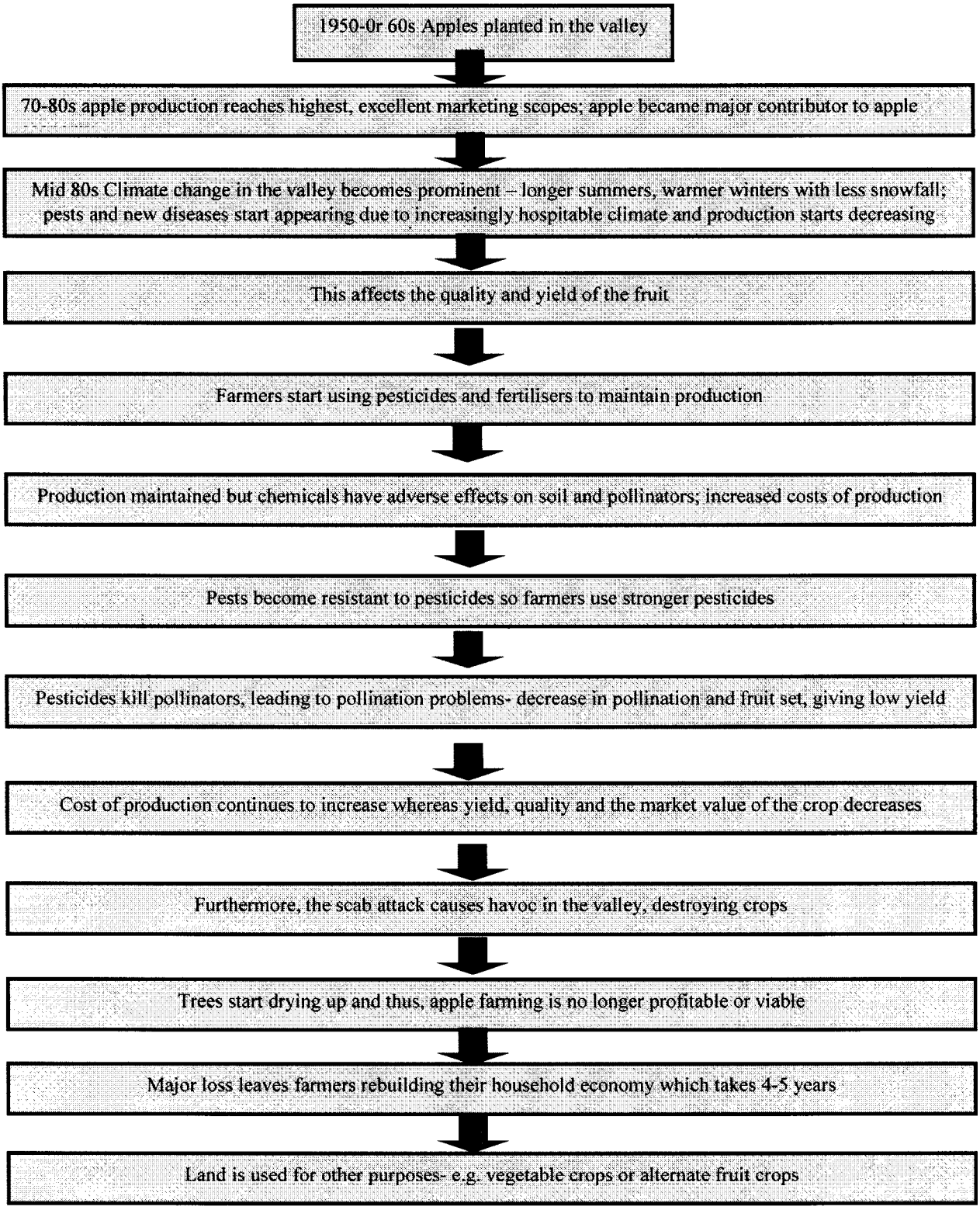
Table 6: Land use after the phasing out of apples (% of farmers' responses)	
Parameter	**% of response**
Crops replacing apple farming	
• Vegetables and wheat/ maize	20
• Vegetables, fruits and wheat/ maize	35
• Vegetables and fruits	25
• Fruit only	20
Contribution of current crops to household income (%)	
• Av. 91 (65-100)	60
• Av. 45 (35-50)	40
Comparative economic benefit of present crops to apples.	
• More beneficial than apples	40
• Less beneficial than apples	45
• About the same	15
Time taken to restore farm economy after apple decline	
• 2-3 years	35
• 4-5 years	65
Change from apple to other crops	
• Process oriented	40
• Abrupt change (removed orchards immediately	60
Additional Note: Wheat maize is only grown for self consumption Vegetable crops include: Cauliflower, cabbage, tomato, brinjal, potato, chillies Fruit crops include: Plum, pear, pomegranate, kiwi, persimmon, peach, almonds, walnut and pecan nut	

Analysis of Survey Findings:

In this area, the apple economy failed due to the general rise in temperatures throughout the valley and subsequent changes in the local climate. It is clear apple farming cannot be resumed now as the climate does not support it. The failure of apple farming affected the household economy of farmers as their income source was hindered, pushing many of them into loss and causing financial difficulties. It was a major negative impact that climate change brought on the area.

However, the climate change supported cultivation of other crops. It cannot be denied that the figures show that quite a large proportion of previous apple farmers are benefiting from their present farming activities. Figures in Table 6 emphasise that for 55 percent of the farmers, the farming options of the post apple period are proving to be economically more or equally beneficial than apple. The climate change that pushed them through a painful experience for a short period of time made all this possible. Figure 3 shows the process of impact of climate change on apple economy in lower valley.

Figure 3: Flow chart showing the process of change in the apple economy in the lower valley of Kullu, as described by the Key informants



LOCATION B: Upper Kullu Valley, Villages; Burua and Vashist

Currently in the boom period:

Similar to Location A, this area predominantly consists of small and marginal farmers. They have planted orchards on 42% of their land and of all the farmers interviewed, apple provides over 80% of the household income for 90 percent of them, with 50% of the total being fully dependent upon the income brought in by apple farming. It highlights how crucial and beneficial this activity is proving for them in supporting their livelihood.

Photograph 3: Apples in a farm in Burua

Table 7: Farmers' apple orchard holdings and income levels of surveyed households		
Parameter	**Average Value**	**Range**
Av. Farm size (ha)	1.46	0.56-3.2
Av. Orchard size (ha)	0.62	0.08-1.04
Contribution of apples to household income (%)	For 50% of the farmers, apple contributes 100% of family income For 40% of the farmers, apple contributes 80% of family income For 10% of the farmers, apple contributes 41% of family income	- 70-90 30-50
Changes brought by apple economy in living standards and social development	Increased expenses on education, health, piped drinking water, better housing , electricity, phones, vehicles	-
Apple orchards planted (year)	1963-85 (some in mid 60s but major plantations in 1980s)	-
Difference in household income brought by apple farming	Apples improved family income significantly i.e. Av 50 times (e.g. from Rs 2000 to 100,000)	-
Crops introduced alongside apples	Nothing, but farmers continued to grow food crops (rice, pulses, mustard, vegetables) for their own use	-
Farmers still expanding apple plantations on new plots • Yes • No	 80 20	

All the farmers reported that the income generated from apple farming was much more as compared to their previous farming activities (Photograph 3). It enabled them to improve their housing, provide their children with better education and increase their living standards and social status in general. The apple trees were planted by farmers between 1963- 1985 and a majority of the farmers are still expanding their orchards (Table 7).

A comparison to the pre apple farming economy:

Before farmers in the upper valley areas shifted to apple farming, 50 percent of farmers said they heavily relied on either cultivation of crops such as barley, wheat and millet for self consumption; the other 50 percent depended on income from livestock rearing and pastoral farming. Overall, their subsistent needs were hardly met and income sources were low. Previously they earned their livelihoods by selling livestock and wool.

Table 8: Factors behind shift to apple farming in villages of Upper Kullu Valley and other income generating activities before and after apple farming

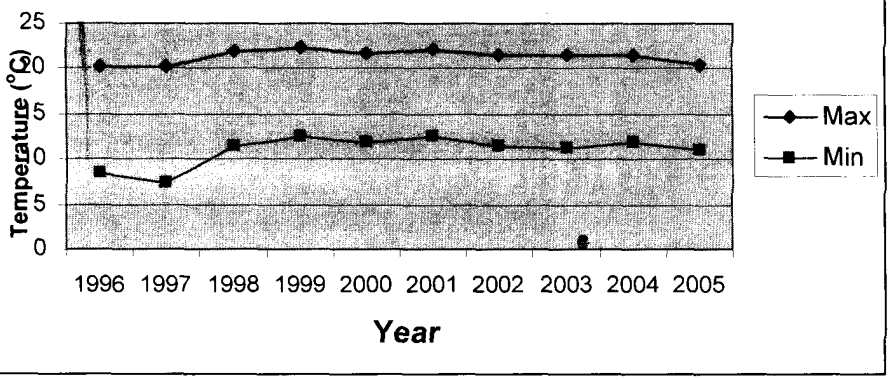
Parameter	% of response
Why apples were not planted before	
• Unsuitable climate (heavy snowfall, low temperature)	50
• Lack of awareness/ uneducated	50
Changes that made apple growing possible	
• Increased awareness/ education	40
• Suitable climate (appropriate snowfall and temperature)	10
• Both climatic suitability and awareness	50
Crops/ activities replaced by apples	
• Cultivation of subsistence crops(barley, millet, maize and wheat) reduced	40
• Pastoral farming (sheep and goat herders)	40
• No response	20
Type of farming before apple orchards changed farm economy	
• Subsistent crop-livestock farming	10
• Semi- nomadic pastoral farming (sheep & goats)	60
• Partly both of the above	30
Present sideline activities taken by family members to supplement family income	
• Tourism services	60
• Tourism related shop keeping in season	20
• No response	20

Most of the farmers said they were uneducated about such activities, but when awareness of alternative income generating activities spread, foreseeing a greater economic benefit in apple farming, they shifted towards apple planting. Half of the farmers also mentioned that previously, the climate to plant apples was not suitable. Apple trees before would not survive in the harsh climate with too much snowfall, but with increasing temperatures throughout the valley, the climate altered and became accommodating to the apple crop. Apart from apple farming, 80% of the farmers are also engaged in the tourism sector to generate and further supplement family income. These range from taxi service to guides etc (Table 8).

Climate Change:

All of the farmers indicated that the glaciers were retreating. The data below also reveals a general increase in the average annual temperatures. Lower and increasingly irregular rainfall had led to altered weather patterns and changed *season lengths*[10] (Figures 4&5). The factor that seems to pose the most threat for the future as 100% farmers pointed out and agreed upon, is reduced snowfall, the essential 'white manure' for apples. In the upper areas climate has altered from being too cold to being hospitable to the apple. Many expressed concern that continued change in climate may eventually make it too warm to grow apples, like in the lower areas. (See also Table 9)

Figure 4: Changes in average temperature in upper valley of Kullu over the last decade (Source: Temperate Vegetable Research Station, IARI, Katrain)



The graph above does not show any drastic change in temperature. The slight overall rise is just visible. However, this slight rise has had a great impact on overall climatic conditions in the area. On Figure 6 we see the erratic nature the rainfall has acquired and how much it has reduced on the whole.

[10] Previously, farmers could only plant crops from May to June. From October onwards, heavy snowfall was liable to damage the crops. However, now cropping season extends from as early as March to November.

Figure 5: Average annual rainfall (mm) recorded at Katrain, Upper Valley of Kullu (Source: Temperate Vegetable Research Station, IARI, Katrain)

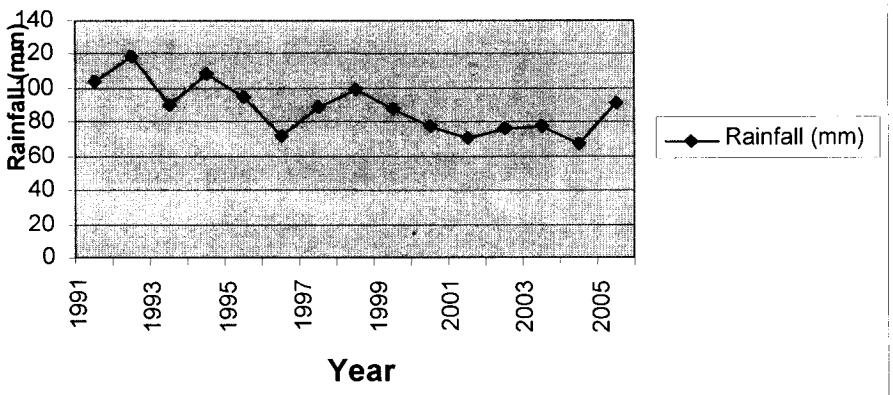
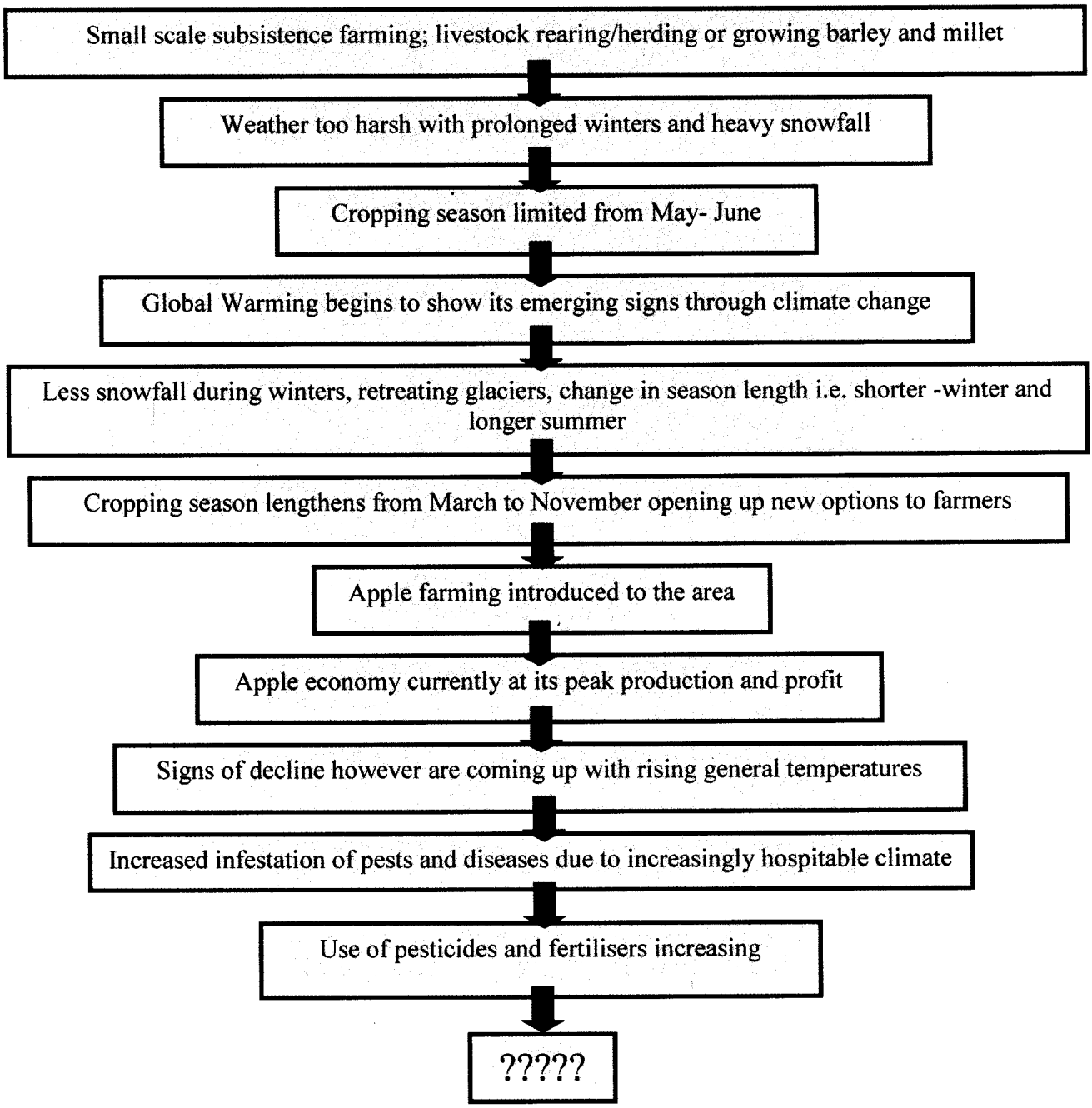


Table 9: Folk indicators of climate change and impact on apple farming	
Parameter	**% of response**
Farmers observations of climate change (less snowfall, increased temperature, glacier retreat, change in seasons- long summers, short winters and changed rainfall pattern)	100
Attack of diseases and pests	
• Yes	90
• No	10
Use of pesticides and fertilisers	100
Increase in cost of production	
• Yes	90
• No	10
Impact on pollinators	
• Population reduced due to pesticides	70
• No awareness	30
Quality of apples	
• Good	40
• Good, but not as good as twenty years ago	60
Is apple farming still profitable	
• Yes	20
• Yes, but not as profitable as before	80
Replacement of apples being considered	
• Yes	0
• No (even with rising costs of production)	100

Figure 6: A flow chart showing the process of change in the agricultural economy of farmers in the Upper Kullu Valley



Conclusion:

The study establishes the effects of global warming on agriculture which people are experiencing locally in the Kullu Valley. Climate change forced these mountain farmers to abandon one set of crops and adopt new ones as the unsuitable climatic conditions made it uneconomic and unprofitable for farmers to continue growing apples in the lower valley while it made it possible to grow them in the upper valley. Although some farmers may be unaware of the global warming concept, they are nonetheless conscious of increasing average temperatures in their area over the years and the increasingly unpredictable nature the weather has acquired such as erratic precipitation in both upper and lower valley regions.

'Agriculture is the main occupation of around three-quarters of the total rural population'[11] and apple has always been one of the primary fruit crops and a major source of income for farmers in the Kullu Valley. However, due to climatic change it has been forced to be abandoned in many areas.

In the lower valley areas, the main reason why the apple economy crashed was due to poor yield and quality. This was the result of climate change combined with already low market prices for the apple crop which thus, fell even lower.

The previously prospering apple farmers in the lower areas went through a painful decline process, however the identification of new farming options such as vegetables and other fruits, coupled with government support resulted in a positive outcome. Climate change opened up new and in general more profiting farming options to the lower valley farmers.

Similarly, in the upper valley, the altered climate encouraged the adoption of new crop options i.e. apple farming, which brought prosperity into the household economies and society. The area saw a general ascent in living standards of most farmers.

The agricultural sector is highly sensitive to climatic conditions of all human activities and easily impacted. In this case we saw the upward shifting of the apple belt and the discovery of better/new options. However, the change may not always be positive.

Here we land on one of the uncertainties of climate change impact on agriculture which leaves us with many unanswered questions. What impact will climate change have on world agriculture? How long will these diversified options last before the climate takes another turn?

There is definitely a visible knowledge gap between present and the future impact of global warming on agriculture worldwide. More research needs to be carried out to enhance our understanding of likely impacts of climate change. However there is no doubt that these changes will bring about major transformations in agriculture in different areas of the world.

Overall, this research evaluates the long term and short term effects of global warming on mountain agriculture . The results of this investigation give us an understanding of future of agriculture if the rising effects of climate change are not curbed.

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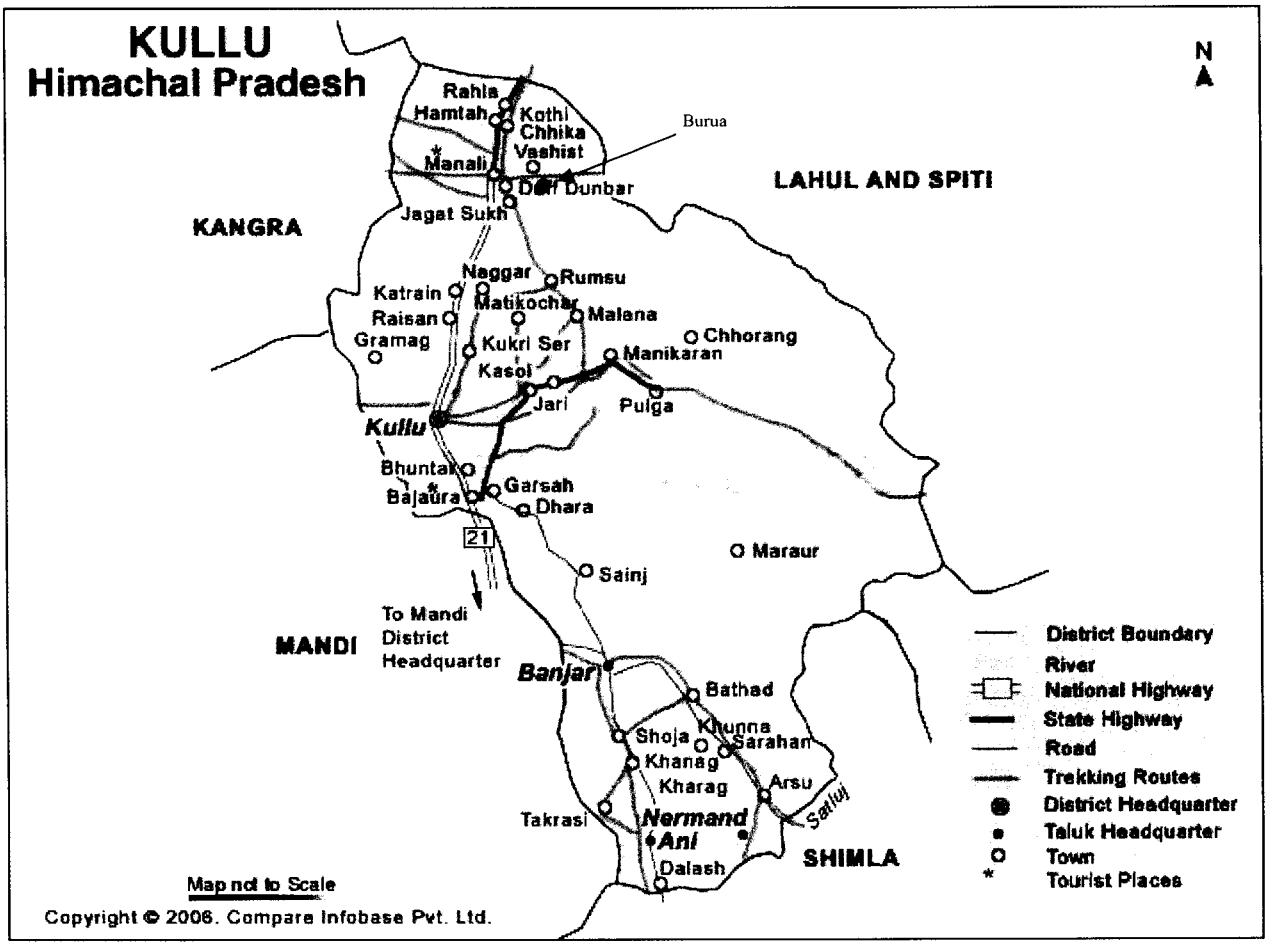
[11] Partap, U. and Partap, T. (2002). *"Warning Signals From the Apple Valleys of the Hindu Kush-Himalayas"*. Nepal: International Centre for Integrated Mountain Development

Annexure-1

Map of Kullu district of Himachal Pradesh showing study sites



Annexure –1

The highland Village Kothi

The Kothi area was taken for the study as it was situated at the top most part of the apple belt at 2500m where apple farming has recently begun. Information gathered through using only key informants revealed that apple farming just started in the area about 15 years ago and the activity is still at the initial growth stage (Photograph 4). The harsh climate and massive snowfall of 5-6 feet did not support the conditions necessary for the apple growth earlier. In comparison to before, the temperature has risen slightly and the amount of snowfall has slightly decreased. At present yield is low and not yet enough for full blown commercial purpose but the apples are of top quality.

Photograph 4: The apple orchard at its beginning stages in Kothi

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